

THE MICROSPORE GENUS *SIMOZONOTRILETES*

by H. J. SULLIVAN

ABSTRACT. The microspore genus *Simozonotriletes* is reinterpreted in the light of new material obtained from three horizons in the Westphalian sequence of Great Britain. The spores are assigned to nine varieties of the type species *Simozonotriletes intortus* (Waltz). The species *S. sublobatus* (Waltz) is reduced to varietal status; *Triquitrites trivalvis* (Waltz) is transferred to *Simozonotriletes* and also recognized as an infraspecific category. The variation in the spore assemblages is described and the stratigraphical occurrences noted.

INTRODUCTION

THIS account deals with the morphological variation exhibited by a group of triangular zonate microspores which have been obtained from a cannel coal at the top of the Middle Fenton Seam and its overlying non-marine shale at the Coldbath opencast site, near Barnsley, Yorkshire (Floral Zone Upper Westphalian A). These spores formed only a small proportion of the total assemblage from any one microscope separation and, in the sense of Raistrick, would be termed 'accessory'. However, in the course of examining a large number of slides over 100 specimens have been recognized, and these have been used to illustrate the present study. Other examples from the cannel coal, Hazelwood opencast site, Coed Talon, Flintshire (Floral Zone Middle Westphalian A); and a cannel coal in the Barnsley Seam, Firbeck Colliery, near Worksop, Nottinghamshire (Floral Zone Middle Westphalian B), have been included in this paper to supplement the evidence provided by the Fenton assemblages.

The spores showed a considerable amount of variation principally in the structure of the exine external to the central area, and in the shape of the grain in proximo-distal orientation. A number of the examples could readily be referred to *Simozonotriletes* Potonié and Kremp, but in addition there were allied forms which possessed characters hitherto undescribed in this genus. Many diverse types were represented, but were all related in that the entire collection displayed continuous morphological variation along certain well-defined trends. The end members of these trends were of widely dissimilar aspect, and on the basis of the existing classifications, the differences could be interpreted as sufficient to warrant generic status. However, since there were no demonstrable discontinuities in the variational pattern all the forms are here considered as constituting one species; any subdivision should therefore be limited to the infraspecific level.

While a trinomial nomenclature may appear cumbersome to the stratigraphical palynologist, whose prime concern is the application of spores to the practical problems of zoning and correlation, it is nevertheless amply justified in that it gives a more precise expression of morphological relationship and possibly also of botanical affinity.

Due regard has been paid to the range and pattern of variation in the erection of taxonomic units. In the analysis of a small number of specimens undue emphasis may be given to individual variants because of the incomplete representation of their relationships. This applies particularly in the present instance when we are dealing with one of the rarer types of spores. If a restricted number of spores had been considered, divorced from the picture of continuous variation which emerges when the total population is

studied, the apparent differences they displayed would have suggested the existence of several species or even genera. The nomenclatural treatment would then have borne no relation to their natural alliance. The evidence is not conclusive to show whether or not these spores were derived from the same species of parent plant, but the close and integrated morphological similarities they display may well suggest a common origin.

The range and pattern of variation of the spores in the shale were comparable in almost every respect to those in the underlying cannel coal, and the assemblages are treated as one in the description of the morphology. The morphological terms used in the designation of the taxonomic units are those defined by Potonié and Kremp (1955, pp. 9–15).

The spores were isolated by macerating a crushed sample of coal with Schulze solution followed by washing with 10 per cent. caustic potash and distilled water. Preliminary treatment with warm hydrofluoric acid was necessary in the case of the shale to remove the mineral matter. Permanent mounts of the microscope separations were made in glycerine jelly and all the slides are now housed in the collection of the Micropalaeontological section of the Geology Department, Sheffield University.

The author is deeply indebted to Professor L. R. Moore for his constant help and guidance throughout all stages of the work, and to Mr. P. C. Sylvester-Bradley for much useful discussion and advice. Mr. R. Neves has read the manuscript and offered a number of suggestions. Thanks are also due to Mr. G. S. Bryant for his help in the production of the plates, and to Miss P. Linnett for her assistance in drawing the text-figures.

The contents of this paper form part of an investigation into the microfloral remains of cannel coals and associated carbonaceous sediments. The work is being carried out at the Geology Department, University of Sheffield, under a tenure of a Town Trustees Fellowship and a State supplemental award.

SYSTEMATIC REVISION

The name *Simozonotriletes* was introduced by Naumova (1937, p. 355) for a 'subgroup' of microspores included in *Zonotriletes* Waltz 1935. The 'subgroup' is now considered equivalent to a taxon of generic rank. Naumova gave only a brief diagnosis and named no species. Three species of spores *Zonotriletes intortus*, *Z. sublobatus*, and *Z. auritus*, described by Waltz in Luber and Waltz (1938), were subsequently transferred to *Simozonotriletes* by Potonié and Kremp (1954, p. 159; 1956a, pp. 109–10). They gave a more complete account of the generic characters and selected *S. intortus* as the type species.

When the genus *Simozonotriletes*, as herein interpreted, is placed within the framework of the classification proposed by Potonié and Kremp (1954), certain inconsistencies arise. It is hoped to discuss the question of its systematic position in a later paper, but a revision of the diagnostic characters used in the definition of the suprageneric taxa of the subdivision Zonales would seem to be indicated.

Genus SIMOZONOTRILETES Potonié and Kremp, 1954

Type species *Simozonotriletes intortus* (Waltz) Potonié and Kremp 1954

Diagnosis. Trilete isospores or microspores; triangular in equatorial plane with convex to markedly concave sides and rounded apices; central area triangular, margin well de-

finer and runs approximately parallel to the equator of the spore; exine levigate to infrapunctate or infragranulate; trilete rays exceed $\frac{2}{3}$ radius of central area; cingulum may be of uniform width and thickness but is frequently wider and thicker at the apices; it can also be differentiated into an outer dark zone and inner light zone; dark zone often expanded and thickened into smooth, pad-like valvae at the apices, and may be absent or discontinuous along the sides; in some forms thickened areas are also present in inter-radial regions; secondary folds absent due to good proximo-distal orientation; extrema lineamenta smooth to sinuous, sometimes incised.

Comparison and remarks. This genus resembles *Triquitrites* Wilson and Coe 1940, but may be distinguished from it by the presence of a well-defined central area. The auriculae in *Tripartites* Schemel 1950 are usually larger and show a tendency to frilling and fluting. *Anulatisporites* Potonié and Kremp 1954 has a more circular outline and the cingulum decreases in thickness towards the equator. Two species of *Simozonotriletes* are now recognized, viz. *S. intortus* and *S. auritus*. These can be differentiated on the basis of the trilete suture. The rays in *S. auritus* possess broad, prominent lips, whereas in *S. intortus* the lips are thin.

Simozonotriletes intortus (Waltz) Potonié and Kremp 1954

Diagnosis. Size 35–110 μ , trilete rays extend almost to the margin of the central area, lips thin, intratectum narrow; remainder as for genus.

Simozonotriletes intortus var. *intortus* (Waltz)

Plate 26, figs. 1–4; text-figs. 1, 2a–c

Zonotriletes intortus Waltz in Lubert and Waltz 1938, pl. 2, fig. 24.

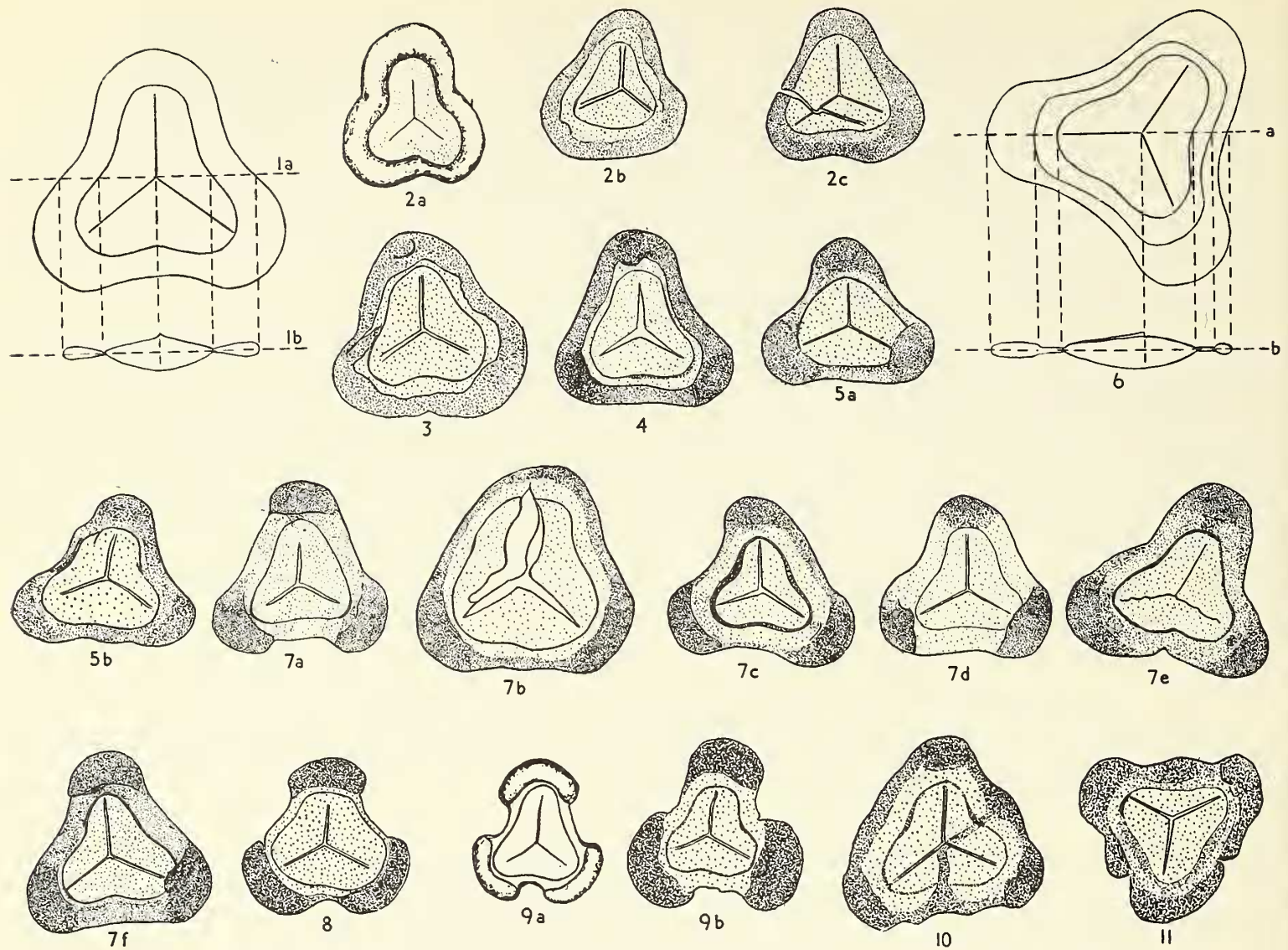
Simozonotriletes intortus (Waltz), Potonié and Kremp 1954, p. 189.

Simozonotriletes intortus (Waltz), Horst 1955, p. 183, pl. 22, figs. 52–54.

Holotype. Plate 2, fig. 24 of Lubert and Waltz (1938), Moscow Brown Coal (reproduced as text-fig. 2a). *Figured material.* Slides M2C1d (152831), M2E7a (168719), M2C1c (295786), Middle Fenton coal and shale, near Barnsley, Yorkshire. Slide M9A3 (355654), Barnsley Seam, near Worksop, Nottinghamshire. Slide 17A1f (182710), Flint Cannel Coal, near Wrexham, Flintshire. All slides are in the collection of the Geology Department, University of Sheffield.

Diagnosis. Size 35–110 μ , holotype (measured from figure) approximately 60 μ ; cingulum homogeneous or may show a division into dark and light zones; dark zone, if present, maintains a uniform width and thickness around the equator; cingulum not expanded and thickened at the apices.

Description. Colour yellow to brown. Triangular in equatorial outline with slightly concave or convex sides and rounded apices. The exine of the central area is levigate to infragranulate and often shows evidence of corrosion and decay. Trilete rays long and straight, extend almost to margin of central area. Some of the forms (e.g. text-fig. 2a; Pl. 26, fig. 1) possess an undifferentiated cingulum which is rounded at the equator (text-fig. 1), but in others (Pl. 26, fig. 4; text-fig. 2b) dark and light zones are present. In the spore figured on Pl. 26, fig. 3 the cingulum tends to be wider in the interradial regions where it overlaps on to the central area.

TEXT-FIGS. 1-11. *Simozonotriletes intortus* (Waltz).

Figs. 1, 2, var. *intortus* (Waltz). 1a, b, diagrammatic representation of polar view and hypothetical meridional section, with undifferentiated cingulum. 2a, holotype redrawn from Luber and Waltz (1938), $\times 275$. 2b, slide M2E7a ref. 168719 (see Pl. 26, fig. 2), Fenton shale, $\times 250$. 2c, slide M17A1f ref. 182710, Flint Cannel Coal, $\times 250$.

Fig. 3, var. *fentonensis* nov., holotype, $\times 250$.

Fig. 4, var. *lineatus* nov., holotype, $\times 250$.

Fig. 5, var. *sublobatus* (Waltz), $\times 250$. 5a, slide M1B5 ref. 358698 (see Pl. 26, fig. 11), Fenton Cannel Coal. 5b, slide M2E4 ref. 169767, Fenton shale.

Figs. 6, 7, var. *polymorphosus* nov. 6a, b, diagrammatic representation of polar and hypothetical meridional section. 7a, holotype. 7b, slide M2C1e ref. 208695. 7c, slide M2E7 ref. 101845. 7d, slide M2E7a ref. 237769. 7e, slide M1B5 ref. 338647. 7f, slide M1B4 ref. 210763 (see Pl. 27, fig. 11). 7a, c, d from Fenton shale, $\times 250$; 7b, e, f from Fenton Cannel Coal, $\times 250$.

Fig. 8, var. *concavus* nov., holotype, $\times 250$.

Fig. 9, var. *trivalvis* (Waltz), $\times 250$. 9a, holotype, redrawn from Luber and Waltz 1938. 9b, slide M2E7b ref. 460653 (see Pl. 28, fig. 3), Fenton shale.

Fig. 10, var. *reinschi* nov., holotype, $\times 250$.

Fig. 11, var. *mediolobatus* nov., holotype, $\times 250$.

Remarks. The spores which have previously been described as *S. intortus* are all included in this variety. The size limits of our examples, based on the measurement of twenty-three specimens, were 66-110 μ ; the mean was 79.5 μ , and the standard deviation 14.0 μ . Reinsch (1884) figured many spores which are comparable to *S. intortus* var. *intortus*. These were included in the subdivisions VIII and XIV of subfamily 1 (nucleus triangu-

laris) and are listed here: pl. 4, figs. 45, 47, 48, 51, 51A, 54; pl. 5, fig. 58; pl. 6, figs. 77 (right-hand figure), 80, 84, 86; pl. 15, figs. 48A, 51B (given as 51A in explanation of plates), 59A; pl. 18, fig. 106A; pl. 19, fig. 45B; pl. 49B, figs. 1, 6–8. Their dimensions ranged from 35–105 μ . Many of the above forms were assigned by Horst (1955, p. 184) to *S. intortus*. In the description of subdivision XIV Reinsch states ‘exosporium bi-tri-lamelosum’ which in some cases probably indicates a differentiated cingulum.

The type 4K of Knox (1942, fig. 4, p. 6; 1947, fig. 45) from the Limestone Coal Group of Northumberland and Fife, and the Middle Coal Measures of Cumberland resembles *S. intortus* var. *intortus*.

Occurrence. Karaganda Basin, Russia (after Lubert and Waltz 1938), Tournaisian–Viséan. Central Russia (after Reinsch 1884), Carboniferous. Western Upper Silesia (after Horst 1955), Westphalian A. Moravska Ostrava (after Horst 1955), Namurian B. Fife and Northumberland (after Knox 1942, 1947), Lower Carboniferous. Cumberland (after Knox 1942), Westphalian. Yorkshire, Middle Fenton Cannel Coal and shale, Upper Westphalian A; Barnsley Seam, Middle Westphalian B. Flintshire, Cannel Coal, Middle Westphalian A.

Simozonotriletes intortus var. *fentonensis* nov.

Plate 26, figs. 5–6; text-fig. 3

Holotype. Slide M1B4 ref. 250847 in the collection of the Geology Department, Sheffield University, from Middle Fenton Cannel Coal, Coldbath opencast site, near Barnsley, Yorkshire. Upper Westphalian A.

Diagnosis. Size 85–95 μ , holotype 88 μ ; triangular in equatorial outline with convex or concave sides and rounded apices; dark zone of cingulum is of constant thickness, but tends to be wider at the apices.

Description. Colour yellow, dark zone brown. Equatorial outline is triangular with convex or concave sides and rounded apices. Central area often corroded, exine finely infrapunctate to infragranulate. Trilete rays about $\frac{3}{4}$ radius of central area. Cingulum is differentiated into dark and light zones. Inner margin of dark zone is irregular in outline, but tends to be wider at the apices where it may overlap on to the central area. Apices not thickened.

Comparison and remarks. In *S. intortus* var. *intortus* the dark zone maintains a uniform width and thickness around the equator. A total of nine specimens were assigned to *S. intortus* var. *fentonensis*; the mean was 92 μ , and the standard deviation 5 μ . The name *fentonensis* is used to denote the horizon of the type material.

Occurrence. Middle Fenton Cannel Coal and shale, Upper Westphalian A.

Simozonotriletes intortus var. *lineatus* nov.

Plate 26, figs. 7–9; text-fig. 4

Holotype. Slide M2E4 ref. 258748 in the collection of the Geology Department, University of Sheffield, from shale above the Middle Fenton Seam, Coldbath opencast site, near Barnsley, Yorkshire. Upper Westphalian A.

Diagnosis. Size 75–90 μ , holotype 85 μ , triangular in equatorial outline with straight sides; dark zone continuous along the interradial margins, apices variously thickened; width of dark zone to radius of central area is about 1:1 to 1:2.

Description. Colour yellow, dark zone brown. Equatorial outline triangular with almost straight sides. Trilete rays extend to margin of central area, exine infrapunctate. Cingulum differentiated into dark and light zones, dark zone thickened and sometimes expanded at the apices. Thickening not uniform and may be more pronounced in one of the valvae.

Comparison and remarks. In *S. intortus* var. *polymorphosus* the sides are usually more concave, the dark zone less well defined in interradial regions, and the valvae tend to be larger. The dark zone is not thickened at the apices in *S. intortus* var. *fentonensis*. The size limits of this variety are erected on the measurement of seven specimens. The calculated mean and standard deviation were 82 μ and 4 μ respectively. The name *lineatus* is used to indicate the straight sides which are characteristic of this variety.

Occurrence. Middle Fenton Cannel Coal and shale, Upper Westphalian A.

Simozonotriletes intortus var. *sublobatus* (Waltz)

Plate 26, figs. 10–12; text-figs. 5a, b

Zonotriletes sublobatus Waltz in Luber and Waltz 1938, p. 17, pl. 2, fig. 22.

Simozonotriletes sublobatus (Waltz), Potonié and Kremp 1956a, p. 110.

Holotype. Plate 2, fig. 22 of Luber and Waltz (1938). *Figured material.* Slides M1B4 (144639), M1B5 (358698), M1B1 (258791), M2E4 (169767) in the collection of the Geology Department, University of Sheffield, from the Middle Fenton Cannel Coal and shale, Coldbath opencast site, near Barnsley, Yorkshire. Upper Westphalian A.

Diagnosis. Size 35–80 μ , holotype (measured from figure) approximately 60 μ ; cingulum displays no clear differentiation into dark and light zones, and is wider and thicker at the apices.

Description. Colour yellow to brown. Triangular in equatorial outline with straight to concave sides and rounded apices. Central area outline may be indistinct, exine levigate to infrapunctate. Trilete rays exceed $\frac{3}{4}$ radius of central area, suture usually closed. The cingulum shows no clear differentiation into dark and light zones in the interradial region, and is expanded and thickened at the apices. Thickening is irregular and may be more marked at one apex. Inner margin of the valvae sometimes overlap on to the central area.

Comparison and remarks. The differential thickening of the cingulum is not as marked as in *S. intortus* var. *polymorphosus*. The dimensions of the forms found by Waltz, and described under *Zonotriletes sublobatus*, ranged from 37.5 to 60 μ . He noted that the cingulum was smooth, and thickened and expanded at the apices. To conform with the original diagnosis *S. intortus* var. *sublobatus* is now restricted to forms in which the undifferentiated cingulum is wider and thicker at the apices. The maximum diameter of fourteen specimens obtained from the Fenton horizon varied between 66.5 and 80 μ . They possessed a mean diameter of 73 μ , and had a standard deviation of 5 μ . The figure

of Reinsch (1884, pl. 6, fig. 77) was referred by Waltz to his species *Zonotriletes sublobatus*. The spore figured in Reinsch (1884, pl. 3, fig. 34) is also included here.

Occurrence. Karaganda Basin, Russia (after Lubert and Waltz 1938), Tournaisian-Viséan. Pruckscha, central Russia (after Reinsch 1884), Carboniferous. Middle Fenton Cannel Coal and shale, Upper Westphalian A.

Simozonotriletes intortus var. *polymorphosus* nov.

Plate 27, figs. 1-12; text-figs. 7a-f

Holotype. Slide M2E7a ref. 196712 in the collection of the Geology Department, University of Sheffield, from the shale above the Middle Fenton Seam, Coldbath opencast site, near Barnsley, Yorkshire. Upper Westphalian A.

Diagnosis. Size 60-100 μ , holotype 81.5 μ ; apices thickened, cingulum in interradianal regions may be homogeneous or differentiated into dark and light zones; dark zones, if present, are usually absent from one or more of the sides.

Description. Colour yellow, valvae brown. Equatorial outline triangular with straight to concave sides and rounded apices. Central area outline distinct, exine levigate to infrapunctate. The trilete rays exceed $\frac{3}{4}$ of the radius of the central area. Apical regions of the cingulum are thickened, the form of the valvae being dependent on the configuration of the apices. The inner boundary of the valvae may overlap on to the central area (e.g. Pl. 27, fig. 12).

Comparison and remarks. In *S. intortus* var. *concavus* the sides are more concave, the apices more rounded, and the cingulum tends to be narrower along the margins. In *S. intortus* var. *lineatus* there is a well-defined dark zone between the valvae. *S. intortus* var. *polymorphosus* was the dominant variety present in the Fenton assemblages. A total of thirty specimens were recognized, having a mean and standard deviation of 83 μ and 7.5 μ . The spore on pl. 6, fig. 79 of Reinsch (1884) resembles *S. intortus* var. *polymorphosus*. The name *polymorphosus* is used to indicate the wide variation displayed by forms assigned to this variety.

Occurrence. Zwickau, Saxony; and Towarkowa, central Russia (both after Reinsch 1884), Carboniferous. Middle Fenton Cannel Coal and shale, Upper Westphalian A.

Simozonotriletes intortus var. *concavus* nov.

Plate 28, figs. 1-2; text-fig. 8

Holotype. Slide M1B2 ref. 342845 in the collection of the Geology Department, University of Sheffield, from the Middle Fenton Cannel Coal, Coldbath opencast site, near Barnsley, Yorkshire. Upper Westphalian A.

Diagnosis. Size 60-90 μ , holotype 80 μ ; sides concave, apices broad and rounded, cingulum in interradianal regions is narrow (up to about 8 μ), and expanded and thickened into valvae at the apices; inner lines of valvae may overlap on to the central area.

Description. Colour yellow, apices brown. Triangular in equatorial outline with concave sides and broad rounded apices. Exine of central area is infrapunctate to infragranulate,

rays frequently open and are about $\frac{3}{4}$ radius of central area. Valvae are present at the apices which may be joined by a narrow, ill-defined dark zone along one or more of the interradial regions.

Comparison and remarks. In *S. intortus* var. *trivalvis* the valvae are more prominent and there is no dark zone along the margins. The mean and standard deviation of the five specimens included in this variety were $73.5\ \mu$ and $8.5\ \mu$ respectively. The figure of Reinsch (1884, pl. 6, fig. 78) is probably *S. intortus* var. *concavus*. The varietal name denotes the concave sides characteristic of the forms included here.

Occurrence. Malowka, central Russia (after Reinsch 1884), Carboniferous. Middle Fenton Cannel Coal and shale, Upper Westphalian A. Barnsley Coal, Middle Westphalian B.

Simozonotriletes intortus var. *trivalvis* (Waltz)

Plate 28, fig. 3; text-figs. 9a, b

Zonotriletes trivalvis Waltz in Luber and Waltz 1938, p. 18, pl. 4, fig. 41.

Triquitites trivalvis (Waltz), Potonié and Kremp 1956a, p. 88.

Holotype. Plate 4, fig. 41 of Luber and Waltz (1938), reproduced here as text-fig. 9a. *Figured material.* Slide M2E7b ref. 460653 in the collection of the Geology Department of the University of Sheffield, from the Middle Fenton shale, Coldbath opencast site, near Barnsley, Yorkshire. Upper Westphalian A.

Diagnosis. Size 45–80 μ , holotype (measured from figure) approximately 65 μ ; equatorial outline trefoil in shape with markedly concave sides and prominent apices; three equatorial auriculae lie opposite the angles of the central area; the remainder of the equatorial region unthickened.

Description. Colour yellow, auriculae brown. Triangular in transverse plane, sides concave, apices broad and well rounded. Margin of central area less concave, exine levigate to finely infrapunctate. The trilete rays are distinct and exceed $\frac{3}{4}$ radius of central area. The auriculae are smooth, pad-like thickenings of the exine. The structureless, unthickened equatorial region is narrow along the interradial margins and may be absent at the apices.

EXPLANATION OF PLATE 26

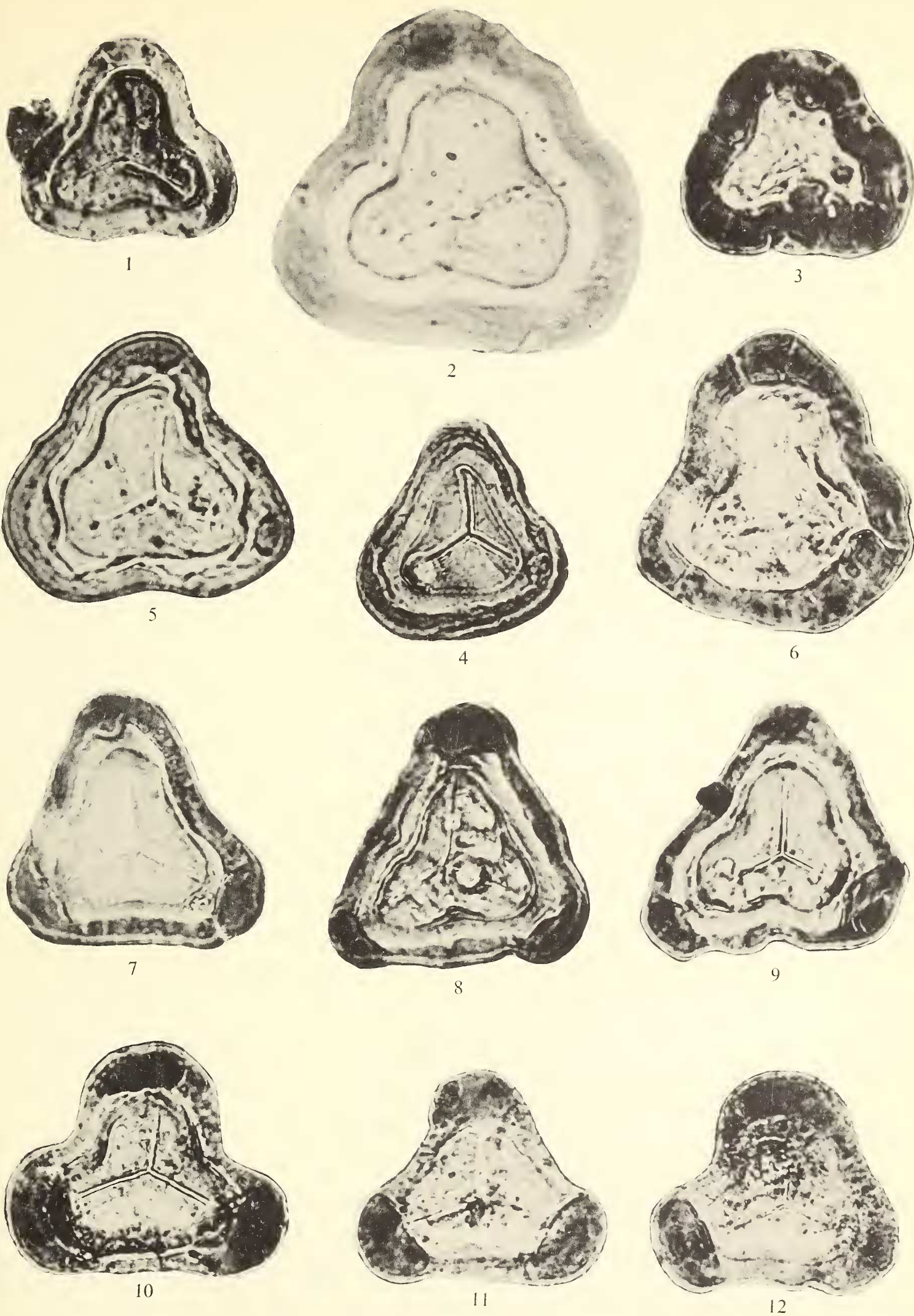
All figures $\times 500$

Figs. 1–4. *Simozonotriletes intortus* var. *intortus* (Waltz). 1, Fenton cannel coal, slide M2C1d ref. 152831—66.5 μ . 2, Barnsley coal, slide M9A3 ref. 355654—107 μ . 3, Fenton cannel coal, slide M2C1c ref. 295786—71 μ . 4, Fenton shale, slide M2E7a ref. 168719—66.5 μ .

Figs. 5–6. *Simozonotriletes intortus* var. *fentonensis* nov. 5, Holotype, Fenton cannel coal, Slide M1B4 ref. 250847—88 μ . 6, Fenton cannel coal, slide M2C1f ref. 261796—93 μ .

Figs. 7–9. *Simozonotriletes intortus* var. *lineatus* nov. 7, Holotype, Fenton shale, slide M2E4 ref. 258748—85 μ . 8, Fenton shale, slide M2E2 ref. 221812—83 μ . 9, Fenton shale, slide M2E7a ref. 158817—84 μ .

Figs. 10–12. *Simozonotriletes intortus* var. *sublobatus* (Waltz). 10, Fenton cannel coal, slide M1B4 ref. 144639—83 μ . 11, Fenton cannel coal, slide M1B5 ref. 358698—75 μ . 12, Fenton cannel coal, slide M1B1 ref. 258791—76 μ .



SULLIVAN, *Simozonotriletes*

Comparison and remarks. *S. intortus* var. *trivalvis* resembles *S. intortus* var. *concauus*, but the auriculae are larger and more prominent. Although represented by only two specimens in the Fenton assemblages, their distinctive nature warranted varietal discrimination. The morphological characters they displayed were in complete harmony with the original diagnosis of *Z. trivalvis* Waltz. The maximum diameters of the two spores were $76\ \mu$ and $80\ \mu$.

Potonié and Kremp (1956a, p. 88) placed this form in *Triquitites* Wilson and Coe. The auriculae are similar in construction to those of *Triquitites*, but the presence of a well-defined central area obviates its inclusion in that genus. The specimen figured by Reinsch (1884, pl. 24, fig. 79D) was referred by Waltz to his species *Z. trivalvis*.

Occurrence. Karaganda Basin, Russia (after Luber and Waltz 1938), Tournaisian–Viséan. Central Russia (after Reinsch 1884), Carboniferous. Middle Fenton shale, Upper Westphalian A.

Simozonotriletes intortus var. *reinschi* nov.

Plate 28, figs. 4–9; text-fig. 10

Holotype. Slide M2E7b ref. 465792 in the collection of the Geology Department, University of Sheffield, from the shales above the Middle Fenton Seam, Coldbath opencast site, near Barnsley, Yorkshire. Upper Westphalian A.

Diagnosis. Size 75 – $90\ \mu$, holotype $91\ \mu$; thickened areas present along the interradiial margins which may extend as narrow bands over the proximal and distal surfaces of the central area; width of cingulum is $\frac{1}{2}$ – $\frac{2}{3}$ radius of the central area; extrema lineamenta sinuous.

Description. Equatorial outline triangular with slightly concave or convex sides and rounded apices. Cingulum differentiated into an outer dark zone and inner light zone. Dark zone often expanded and thickened at the apices. The presence of thickened areas in the interradiial regions of the spore is diagnostic of this variety. The thickening may originate in the dark zone (e.g. Pl. 28, figs. 4, 6; text-fig. 10), or at the junction of the cingulum and central area (Pl. 28, fig. 7). In some forms the thickening continues on to the proximal and distal surfaces of the central area; in the holotype (Pl. 28, fig. 4; text-fig. 10) the thickened bands extend to points above and below the intersection of the trilete rays.

Remarks. The mean diameter of the six specimens referred to this variety was $84.5\ \mu$ and the standard deviation $3.5\ \mu$. Reinsch, to whom this variety is dedicated, figured (1884, pl. 17, fig. 79C) a specimen from the 'Blatterkohle', Malowka, central Russia, which shows thickened areas in the dark zone of the cingulum.

Occurrence. Malowka, central Russia (after Reinsch), Carboniferous. Middle Fenton Cannel Coal and shale, Upper Westphalian A.

Simozonotriletes intortus var. *mediolobatus* nov.

Plate 28, figs. 10–12; text-fig. 11

Holotype. Slide M2E7b ref. 248685 in the collection of the Geology Department, University of Sheffield, from the shale above the Middle Fenton Seam, Coldbath opencast site, near Barnsley, Yorkshire. Upper Westphalian A.

Diagnosis. Size 60–90 μ , holotype 81.5 μ ; cingulum in interradian regions is inciso-lobate; width of cingulum to radius of central area is in the ratio 1:3 to 2:5.

Description. Equatorial outline triangular with almost straight sides. Apices are rounded and sometimes thickened. The cingulum is differentiated into an inner light zone and outer dark zone. The equatorial margin is broken up into a number of lobate structures.

Comparison and remarks. *S. intortus* var. *mediolobatus* and var. *reinschi* are both characterized by complications of the cingulum along the interradian margins. The size limits of this variety were erected on the measurement of five specimens. The mean diameter was 74.5 μ and the standard deviation 10.5 μ . The name refers to the lobate nature of the margin.

Occurrence. Middle Fenton Cannel Coal and shale, Upper Westphalian A.

GENERAL DESCRIPTION OF THE VARIATION

The study of the variation has been concerned with the structure of the equatorial region, the shape of the spore in proximo-distal orientation, and the nature of the central area. The general triangular shape and the presence of a well-defined, sculptureless central area with long simple trilete rays are features shared by all the spores, and can be taken as indicative of their specific identity. The modifications of the cingulum, although producing a wide variety of structures, do nevertheless take place along certain well-defined trends. The assemblages represent a continuously intergrading sequence of forms and it is solely for ease of reference and communication that the infraspecific categories are erected. The overall result of this gradation is to give rise to spores which display considerable differences in external form at the ends of several transitional series. Within the limits of the extreme examples any differentiation of the intermediate types is often a matter of conjecture and mainly dependent on the choice of a single variable character as the basis for subdivision. Such a character of prime importance in this particular group of spores is the cingulum, but the shape of the spore has been accorded a secondary role in the definition of the nomenclatural units.

The cingulum in its simplest case is a homogeneous equatorial border which is rounded at the equator and decreases in thickness towards the junction with the central area. A possible reconstruction is given in text-fig. 1. Spores which possess such a cingulum (Pl. 26, fig. 1; text-fig. 2a) are referred to *S. intortus* var. *intortus*; likewise the examples in which the dark and light zone of the cingulum maintain a constant width and thick-

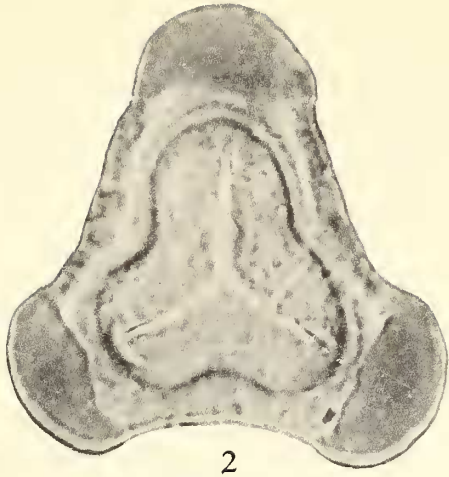
EXPLANATION OF PLATE 27

All figures $\times 500$ unless otherwise stated

Figs. 1–12. *Simozonotriletes intortus* var. *polymorphosus* nov. 1, Fenton shale, slide M2E4 ref. 207665—92.5 μ . 2, Fenton shale, slide M2E7a ref. 445680—87 μ . 3, Fenton shale, slide M2E7a ref. 234730—86.5 μ . 4, Fenton shale, slide M2E6 ref. 325770—71.5 μ . 5, Fenton shale, slide M2E4 ref. 337726—87.5 μ . 6, Fenton shale, slide M2E6 ref. 238772—80 μ . 7, Fenton shale, slide M2E4 ref. 339778—73.5 μ . Note regular arrangement of hyphae-like structures on the central area. 8, Fenton shale, slide M2E4 ref. 273711—74 μ . 9, Fenton cannel coal, slide M1B3 ref. 311809—77 μ . 10, Holotype, Fenton shale, slide M2E7a ref. 196712—81.5 μ . 11, Fenton cannel coal, slide BM14 ref. 210763—76 μ . 12, Fenton shale, slide M2E6 ref. 238740—91 μ ($\times 675$).



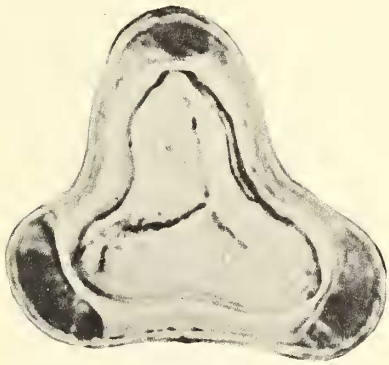
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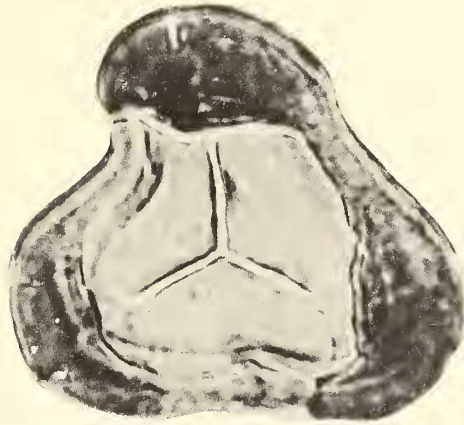
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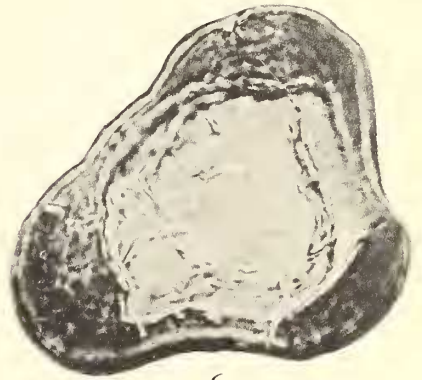
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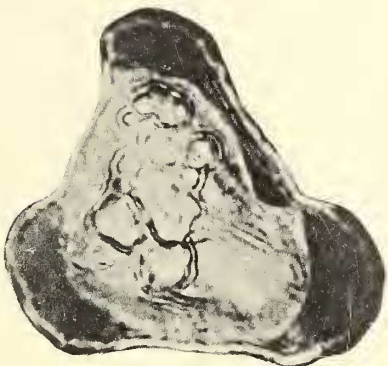
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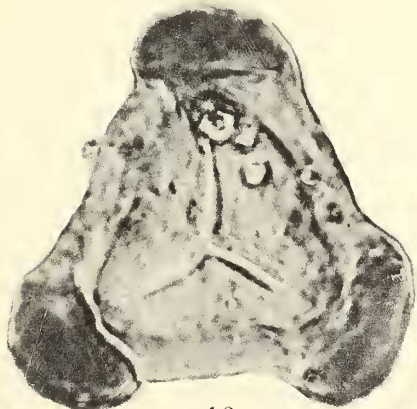
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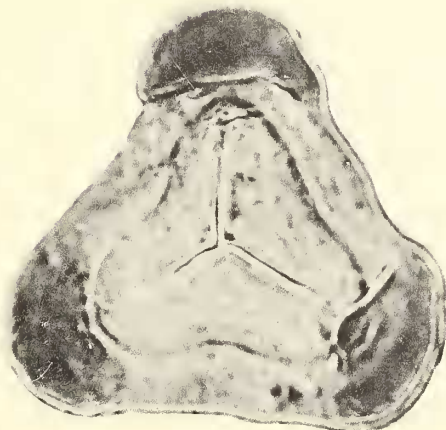
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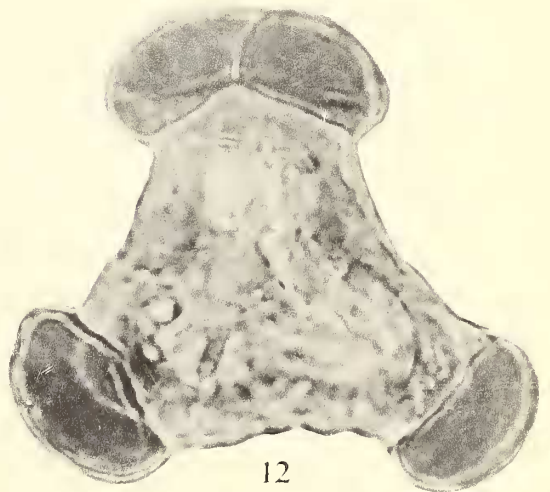
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10



11



12

SULLIVAN, *Simozonotriletes*

